

Gas Dynamics - Video course

COURSE OUTLINE

Review of Fundamentals: Concepts from Fluid Mechanics, Basic Thermodynamic Relations

Compressible flow: Concept of Waves in fluid, Mach waves, Compression waves, Expansion waves

Basic Flow features: Isentropic flow, Shock waves, Stationary and Moving Shocks, Oblique Shocks, Bow Shocks, Expansion Fans

Example flows: Flow around bodies, Shock expansion method for flow over airfoils.

Flow Through a nozzle: Convergent Nozzles, CD Nozzles, Exit Pressure variation vs Stagnation pressure variation.

Oblique shock wave reflections, Jet flows Under- and over-expanded flows Shear layers

Other Non-isentropic flows

Flow with Friction, Friction choking

Flow with heat addition, Thermal choking

Supersonic combustion

Experimental Methods

Shock Tube, Supersonic Wind tunnel, Flow visualization, Supersonic Probes.

Methods of characteristics. Design of nozzles, External flow around bodies

Experimental characteristics of airfoils in compressible flow.

Unsteady flows.

COURSE DETAIL

| S.No | Topic | Sub topics | Number of hours |
|------|-----------------------|---|-----------------|
| 1 | Introductory concepts | Compressibility Thermodynamic concepts Conservation equations Communication in gases Stagnation state | 8.5 |
| 2 | One Dimensional Flow | Pressure waves in gases Communication in gases Stagnation state Differential equations for 1D flow Isentropic Flow with area variations Numerical examples | 1.5 |
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Aerospace Engineering

Pre-requisites:

1. Basic Fluid mechanics, its governing equations and their implications.

Coordinators:

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| 3 | Normal Shocks | Normal Shock Concept Normal Shock relations Moving normal shocks Numerical Examples (stationary & moving) | 7.5 |
| 4 | Oblique shocks | Concept and theory Oblique Shock relations Property variations | 3.5 |
| 5 | Other shocks | Detached Shocks Shock Reflections Numerical Examples Shock-Shock Interactions | 1.5 |
| 6 | Expansions | 1-D Expansion wave Expansion Fan Prandtl Meyer Function Smooth expansions/compressions Numerical Examples | 2 |
| 7 | Shock Expansion Theory | Theory, Examples and its applications | 1.5 |
| 8 | Nozzle flow | Quasi-1D flow with area variations, Geometric Choking Numerical Examples Divergent Nozzles Convergent-Divergent Nozzles Numerical Examples Multiple Choking points | 5 |
| 9 | Supersonic Jet | Jet structure Numerical Examples and Supersonic Shear layers | 3 |
| 10 | Non-isentropic flows | Crocco's Theorem Fanno Flow Numerical Examples Rayleigh Flow Numerical Examples Various Choking mechanisms, Ramjets and scramjets | 7 |
| 11 | Experimental setups | Shock Tubes Compressible flow facilities Measurement Techniques Experiment Design | 5 |
| 12 | Flow visualisation | Schlieren, Shadowgraph, Interferometry | 3 |

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| 13 | 2D Method of Characteristics | Characteristics concept Characteristic directions; and constitutive relations, Subroutines, Marching techniques, Example simulations | 3 |
| 14 | Summary | | 0.5 |
| 15 | Unsteady flow phenomena | | 1.5 |
| | Total Hours | | 54 |

References:

1. Liepmann, H.W., and Roshko, A. Elements of Gas Dynamics Dover Publications, Inc., Mineola, NY, USA.
2. Oosthuizen, P.H., and Carscallen, W.E., Compressible Fluid Flow McGraw-Hill international editions, McGraw-Hill Companies, Inc., Singapore.
3. Babu V. Fundamentals of Gas Dynamics Ane Books India, Chennai.
4. Chapman A.J. and Walker W.F. Introductory Gas Dynamics Holt, Reinhart and Winston, Inc. NY, USA.